Nature of Vowel Sounds.

THE following observations as to the nature of the vowel sounds of a single voice (my own)—details of which form the subject of a separate communication to the journal of the International Phonetic Association—may be of interest.

The sounds were observed by ear, first, for the whispered vowels, and afterwards with a larynx note superimposed. In the whispered series it was found that each of the separate vowels was characterised by *two* resonant notes, an upper component ranging from about ♯d″ (608~) to e″″ (2579~), and a lower component ranging from ♯d′ (304~) to ♯a″ (912~).

The upper components are produced in a manner analogous to that of whistled notes, and their pitch is mainly controlled by the distance of the tongue from the palate and teeth. The same note may be produced with almost any degree of opening of the mouth; about one octave of the scale can be produced—through the nose—with the mouth closed altogether. These notes, for convenience, are referred to as "whistle notes."

The lower components appear to depend, like the pitch of a Helmholtz resonator, largely on the area of the mouth opening—they are referred to as resonator notes.

The two series are independent of each other, so that, for example, an ascending scale of resonator notes and a descending scale of whistle notes may be produced (whispered) simultaneously.

The characteristic whistle and resonator notes for each vowel sound are not absolutely fixed (for an individual voice), but may vary in some cases over as much as 5 semitones without loss of the vowel characteristic.

The ranges of "neighbouring" vowels often overlap, so that two different vowels may have the same whistle or resonator note, but in such cases the other component will be substantially different.

In one or two cases, such as "ii" (eat) and "i" (it) the ranges of *both* components overlap, and the difference between these vowels may be produced in some cases mainly by difference of stress.

When a larynx note is added—as in singing or talking—the pitch of the resonator note does not appear to be affected at all by variations of pitch of the larynx note.

The whistle notes generally are not affected, so long as the pitch of the whistle note in question differs sufficiently widely—say by 2 to 3 octaves—from that of the larynx note.

As the pitch of the larynx note is further raised towards that of the whistle note, the latter tends to adjust itself or "draw" towards the nearest harmonic of the larynx note which lies within its characteristic range for the vowel in question.

Thus, if a chromatic scale be sung to a given vowel sound, the resonator note will remain constant, but when the note sung approaches within say 2 octaves of the whistle note, this latter may be heard to alternate between or jump from one to another of 3 or 4 neighbouring semitones at each change of pitch of the larynx note.

This last phenomenon has, I find, been already observed by Mr. Perrett.

From these observations it would appear to be possible to make an exclusively acoustic classification of the vowel sounds depending on the range of their whistle and resonator notes respectively.

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March 3, 1922.

Protective Colloids—A Pretty Lecture Experiment.

As the result of a large number of experiments carried out in the Chemistry Department of this School by Messrs. Vallance, Dennett, Trobridge, Hammond, and Tidmus in conjunction with the writer, it appears to be a general law that protective colloids or organic emulsoids tend to retard the velocities of such reactions, whether chemical or physical, as involve a change of state in one or more of the components.

Thus it is found that the rates of solution of metals in acids, of corrosion in neutral media, of solution and precipitation of salts, of replacement of one metal by another, as, for example, in the familiar lead-tree experiments, etc., are all retarded by protective colloids. In many cases the rate of retardation conforms to the requirements of the adsorption law. Details of these experiments will be published in due course elsewhere.

A very pretty lecture experiment illustrating this retardation is afforded by the precipitation of mercuric iodide on addition of the chloride to potassium iodide. If this is effected in fairly dilute aqueous solution, the unstable yellow form is first precipitated and rapidly turns from orange to red as it becomes converted to the more stable variety.

If, however, the reaction is carried out in the presence of gelatin, say one per cent., the liquid first turns momentarily yellow, due to the formation of colloidal mercuric iodide, then becomes turbid, and a beautiful canary colour develops, which remains practically unchanged for half an hour or more, according to circumstances. Only very slowly does it change to the red polymorph. The protective colloid retards the growth of the yellow particles. Sunlight accelerates the change markedly. With the aid of the ultramicroscope ($\frac{1}{12}$th inch oil immersion) these changes may be seen beautifully. Drops of gelatin and dilute potassium iodide are mixed under the coverglass and the ultramicroscope focussed as usual. A drop of mercuric chloride solution is brought to the edge of the coverglass and is drawn under by capillary action. The field of the ultramicroscope becomes swept with a stream of luminous particles moving with dazzling velocity—the Brownian movement of the colloidal mercuric iodide. The velocity slows down as the particles increase in size, until the colloid range has been passed, and in a few minutes a fine precipitate is obtained evincing scarcely any movement.

J. NEWTON FRIEND.

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February 27, 1922.

A Problem in Economics.

MANY economic applications of meteorology depend upon the use of forecasts in deciding whether or not to incur expense by taking precautions against some particular phenomenon which would cause damage. A good example is provided by forecasts of ground temperature in deciding whether to pay men to spread sacking over newly-laid concrete road surfaces which would be injured by frost. In the simplest form of such problems the three possible lines of action are (1) to take precautions only on occasions when the phenomenon is forecasted, (2) to take precautions on all occasions, (3) to take no precautions at all. It is of interest to examine the circumstances under which (1) is the most economical line of action.

Let a be the cost of precautions against an event whose probability is P and which will cause damage b if it occurs in the absence of precautions. Suppose the forecast to take the form of a plain "Yes" or "No," and let p be the probability that an occurrence of the event will be preceded by a forecast of "Yes."

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With an unbiassed and experienced forecaster it may be assumed that in the long run "Yes" occurs among the forecasts about as frequently as the event occurs. In a large number n of trials, "Yes" will therefore be forecasted on $\mathrm{P}n$ occasions and the expenditure on precautions will be $a\,.\,\mathrm{P}n$.

The event will occur on $\mathrm{P}n$ occasions of which $p\,.\,\mathrm{P}n$ will have been forecasted. The remaining unforecasted occasions will number $\mathrm{P}n(1-p)$ and will entail an expenditure of $b\,.\,\mathrm{P}n(1-p)$ by damage. The total expenditure will therefore be

$$a\,.\,\mathrm{P}n+b\,.\,\mathrm{P}n(1-p). \quad . \quad . \quad \text{(I.)}$$

The cost of the forecasts is assumed to be negligible in comparison with a and b.

If precautions are always taken the expenditure will be

$$a\,.\,n. \quad . \quad . \quad . \quad . \quad \text{(II.)}$$

If precautions are never taken the expenditure will be

$$b\,.\,\mathrm{P}n. \quad . \quad . \quad . \quad . \quad \text{(III.)}$$

We have now to compare the amounts involved by I., II., and III. and see which is the least.

I. may be written $b\,.\,\mathrm{P}n-(b\,.\,\mathrm{P}n\,.\,p-a\,.\,\mathrm{P}n)$.

The condition for I. to be more economical than III. is therefore

$$b\,.\,\mathrm{P}np-a\,.\,\mathrm{P}n>0$$

or

$$p>a/b.$$

That is to say, the probability of a correct forecast must be greater than the ratio of precautionary expenditure to possible damage. Unless forecasts are very bad or precautions very expensive this condition will be very easily fulfilled.

The condition for I. to be more economical than II. is

$$b\,.\,\mathrm{P}n(1-p)<a\,.\,n(1-\mathrm{P}),$$

which expresses the fact that the loss due to possible damage must be less than the saving through omission of precautions. This may be written

$$1-p<(1/\mathrm{P}-1)\,.\,a/b. \quad . \quad . \quad . \quad \text{(IV.)}$$

With given values of P, a, and b, IV. sets a limit to the allowable error in forecasting. For example, suppose the chances of the event are even, that is $\mathrm{P}=0{\cdot}5$, the following results are obtained for the limiting values:

$$\begin{array}{lllll} a/b= & 0{\cdot}01 & 0{\cdot}05 & 0{\cdot}10 & 0{\cdot}20 \\ p= & 0{\cdot}99 & 0{\cdot}95 & 0{\cdot}90 & 0{\cdot}80 \end{array}$$

If the probability of a correct forecast is not above 0·90 it is therefore disadvantageous to base precautionary action on the forecasts unless it costs more than 1*l.* to save 10*l.* worth of damage.

With lower probability of the event things become much more favourable for (1). Thus suppose $\mathrm{P}=0{\cdot}25$ (chances 3 to 1 against the event) we obtain the following results:

$$\begin{array}{lllll} a/b= & 0{\cdot}01 & 0{\cdot}05 & 0{\cdot}10 & 0{\cdot}20 \\ p= & 0{\cdot}97 & 0{\cdot}85 & 0{\cdot}70 & 0{\cdot}40 \end{array}$$

If in this case the probability of a correct forecast is 0·90 and $a/b=0{\cdot}10$, the expenditure involved per 100 trials, 1*l.* being the precautionary expenditure, works out as follows:

Taking no precautions . . .	250*l.*
Taking precautions on all occasions .	100*l.*
Taking precautions only when the event is forecasted	50*l.*

In practice, the forecaster, being aware that the object of the forecast is to avoid loss by damage, would be biassed in favour of forecasting the event and would only forecast "No" when the odds were considerably against an occurrence. Such a bias would tend to increase p, which was defined as the probability that an occurrence of the event would be successfully forecasted. Against this we would have to set an increased expenditure through needless precautions, and if the forecaster were too cautious this might outweigh the gain resulting from a decrease in unforecasted occurrences. A moderate degree of bias would, however, obviously result in a gain in most cases.

In practice, therefore, the financial results of utilising weather forecasts are likely to be even better than those calculated above.

There is reason to believe that the commercial possibilities of weather forecasts are not fully appreciated. These calculations will serve to show that considerable gain may result from their utilisation, allowing a reasonable margin of error in the forecasts.

E. G. BILHAM.

Age Incidence of Influenza.

THE explanation given by Miss A. D. Betts (NATURE, February 23, p. 240) has always seemed to me an obvious and adequate one. The reply of "The Writer of the Article," that follows it, is admirably clear, and therefore helpful; but I think it really supports the explanation it ostensibly opposes.

Influenza is clearly a disease the incidence and severity of which depend more on the man than on the germ. Some people (apart from the intensive infection and exhaustion of overcrowding and nursing) seem practically immune to it. But all such immunity is probably partial and relative. The successive milder attacks, sometimes not called influenza, that follow a well-marked attack show that the patient is not immune; and any relative immunity is probably largely due to these later successive attacks being treated in time.

In the same way the degree of immunity induced by preventive inoculation is, like other immunity, partial and relative. The inoculated may hope, at least for a time, for substantially increased resistance to infection (but not absolute immunity no matter how intense the infection), and for slighter and briefer attacks if they catch it.

Further, all such relative immunity, if originally present, tends to be destroyed and the severity of the disease and its associated complications increased by exhaustion, whether due to virtuous and patriotic overwork or to vicious dissipation. I do not therefore oppose point (4) of "The Writer of the Article," which is not, however, in dispute here.

But as regards his other three points—

(1) Under end-of-war conditions our young people with unselfish patriotism worked to exhaustion, and largely under conditions involving intensive infection; and as a secondary factor had inadequate food in health and when ill. Again, working as they did largely away from home, the dangerous work of nursing them fell largely on those of their own age, and not, as in normal times, on their parents and elders.

The latter, on the other hand, were not only spared the exhaustion and intensive infection of nursing them, but the "rationing," so trying for the young, was good for us older people, to whom habitual over-eating and drinking is apt to be one of the chief causes of exhaustion and consequent liability to disease, at an age when we should be most immune.

Doubtless the aged were hard hit by the sorrows of the war, which in the end shortened the lives of many; but I take it that, except in the countries actually invaded and ravaged by the enemy, war conditions did not make them more liable to influenza.

(2) Observations on influenza in boarding schools show that those boys who do not readily catch it, and, under normal home conditions, would escape probably entirely, if exposed long enough to the intensive infection of crowded rooms at school, succumb in the

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